Chapter 4

Bicycle Paths

Bicycle paths consist of multiple use paths or trails, separated from motorized vehicular traffic, on which bicycle travel is anticipated and permitted. Bicycle paths may be located within a highway right-of-way or on an independent right-of-way. Because of their expense, bicycle paths seldom are constructed for the exclusive use of bicyclists, but instead must be shared with other users.

Bicycle paths can serve a variety of purposes. They can provide a commuting bicyclist with a shortcut through a residential neighborhood (e.g., a connection between two cul-de-sac streets). Located in a park, they can provide an enjoyable recreational opportunity. Bicycle paths can be located along abandoned railroad rights of way, the banks of rivers, and other similar areas. Bicycle paths can also provide bicycle access to areas that are otherwise served only by limited access highways closed to bicycles. Appropriate locations can be identified during the planning process. Examples of bicycle paths are shown in Figure 34 and Figure 35.

All bicyclists can find bicycle paths inviting places to ride. In addition, since paths augment the roadway system, they can extend circulation options for bicyclists, making trips feasible which might not be feasible if bicyclists had to depend exclusively on roadways. Basic bicyclists and children, however, especially appreciate the freedom from conflicts with motor vehicles which off-road paths promise.

Provision of a bicycle path should not be used as a rationale for prohibiting use of parallel roadways by bicyclists nor as an excuse for not designing such roadways to be compatible with bicycle use. Because of conflicts created by intense usage, differing speed and riding skills of bicyclists and conflicts between users, multiple use recreational paths may often be inappropriate facilities for experienced bicycle riders. In fact, many conflicts on popular multiple use paths can be avoided by encouraging more experienced bicyclists to use parallel roadways.

Figure 34

Example of Bicycle Path

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

1. Planning Issues in Designating Bicycle Paths

a. Shared Use of Multiple Use Paths

As indicated, off-road paths are rarely constructed for the exclusive use of bicyclists, but instead must be shared with other non-motorized users (or, in some instances, with specialized motorized uses such as snowmobiles, off-road motorcycles and similar vehicles).

Just as conflicts can occur between bicycles and pedestrians on sidewalks, or between motor vehicles and bicycles on highways not constructed to compatible standards, heavy use of trails and other multiple use paths can create conflicts between different user groups. Among bicyclists, basic riders and young children who travel at speeds below 15 km/h (9 mph) will conflict with more advanced riders travelling at speeds greater than 20 km/h (12 mph). Pedestrians, in-line skaters and bicyclists, both basic and advanced, will wish to travel at substantially different speeds. So long as the volume of users is low, the conflicts between different groups can be kept manageable. However, even moderate volumes may result in substantial deterioration in level of service and can expose users to substantial safety risks. Conflicts between users are especially likely to occur on regionally significant recreational trails which attract a broad diversity of users.

Figure 35

Example of Bicycle Path

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

b. Regulation of Multiple Use Paths

The types of conflicts on multiple use paths have increased substantially in recent years with the increased popularity of mountain bikes and in-line skating. Methods of addressing these conflicts include providing alternative facilities for different groups, prohibiting certain modes, restricting different modes to specific hours of operation, providing wider facilities or marking wide paths to regulate the flow of traffic. Examples of all of these types of actions can be witnessed along boardwalks in New Jersey where conflicts between different user groups can be especially severe.

c. Incompatible Multiple Use of Paths or Trails

Joint use of paths or trails by bicycles and horses or mountain bikes and hikers pose special problems which in general should be avoided. Horses startle easily and may kick out suddenly if a bicyclist is perceived to be a danger. Furthermore, the surface requirements of a bicycle path are incompatible with the requirements of a bridle path: bicycles function best on hard surfaces, horses best on soft surfaces. A compromise surface to accommodate both would result in a less than adequate surface for both. As a result, where either horseback activity or bicycle activity is anticipated to be high, separate trails are required. Mountain bikes and horses may safely share the use of gravel or dirt trails provided that adequate passing widths are available, the volume of traffic by both modes is low and sight distances permit horses and bicyclists to anticipate and prepare for possible conflicts.

The popularity of mountain bikes has created an increasing problem on hiking trails which have minimal surface improvement and are narrow in width. The speed differential between a mountain bike and a hiker can be substantial. Narrow trails in woods can substantially limit sight distance for mountain bikes and cause riders to either crash into hikers or have near misses. Mountain bike use of hiking trials also results in substantial erosion problems. As a result, use of mountain bikes should be restricted to wider dirt roads and lanes which have adequate sight distance as well as drainage improvements sufficient to protect against trail erosion.

d. Linkage Paths

Conflicts between different users of multiple use paths occur primarily on heavily used recreational trails or in the immediate vicinity of a major pedestrian trip generator. Neighborhood paths and community trails which are used much less intensively will seldom result in conflicts and can be safely shared by a variety of users. Construction of linkages between adjoining residential developments, between schools and neighborhoods or between shopping areas and surrounding streets can substantially expand the circulation opportunities for both pedestrians and bicyclists.

Because such linkage paths are usually short and lightly used, they can almost always be safely shared by different users even if the path's width is minimal. A designer of such a linkage path needs to anticipate the probability of conflicts when designing such a facility. A short path, less than 120 meters (400 feet) in length, in a suburban neighborhood, can usually be constructed to a width of only 1.5 meters (5 feet) provided that adequate sight distance is available to allow a bicyclist to stop when encountering a pedestrian or an opposing bicyclist. This assumes that the probability of encountering a conflicting pedestrian or bicyclist is too small to justify providing the added width needed to pass.

Linkage paths should be required to be constructed when developments are being planned or have been constructed in such a fashion that reasonable pedestrian or bicycle travel is frustrated as a result of a constrained roadway network. Policy for linkages can be defined in the land use element of municipal master plans, in the circulation element of municipal master plans, and on the official map as provided in the Municipal Land Use Law. NJDOT's companion manual, Pedestrian Compatible Planning and Design Guidelines provides additional planning and design guidance regarding the construction of linkage paths.

e. Bicycle Use of Sidewalks

Identifying a sidewalk as a bicycle path is undesirable for a variety of reasons. *Sidewalks are typically designed for pedestrian speed and maneuverability and are not safe for higher speed bicycle use. Conflicts are common between pedestrians traveling at low speeds (or exiting stores, parked cars, etc.) and bicycles, as are conflicts with fixed objects (e.g., parking meters, utility poles, sign posts, bus benches, trees, fire hydrants, mail boxes, etc.). Walkers, joggers, skateboarders, and roller skaters can, and often do, change their speed and direction almost instantaneously, leaving bicycles insufficient time to react to avoid collisions.*

Similarly, pedestrians often have difficulty predicting the direction an oncoming bicyclist will take. At intersections, motorists are often not looking for bicyclists (who are traveling at higher speeds than pedestrians) entering the crosswalk area, particularly when motorists are making a turn. Sight distance is often impaired by buildings, walls, property fences, and shrubs along sidewalks, especially at driveways.

In residential areas, young children can be anticipated to ride bicycles, tricycles, scooters and other riding toys on sidewalks. This type of use is an acceptable exception to the general finding that use of sidewalks by bicyclists is undesirable. Sidewalks in residential areas generally have low pedestrian volumes and are accepted as extended play areas for children. Pedestrians anticipate and usually enjoy encounters with young children who are playing in the sidewalk. This type of bicycle use of the sidewalk is generally acceptable, and provides young children who do not have the judgement or skill to ride in the street an opportunity to develop their riding skills.

f. Bicycle Paths Adjacent to Roadways

Two-way bicycle paths located immediately adjacent to a roadway are not generally recommended for the following reasons:

(1) They require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal Rules of the Road.

(2) When the bicycle path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a bicycle path often travel on the wrong side of the street in getting to the path. Wrong-way travel by bicyclists is a major cause of bicycle/automobile accidents and should be discouraged at every opportunity.

(3) At intersections, motorists entering or crossing the roadway often will not notice bicyclists coming from their right, as they are not expecting contra-flow vehicles. Even bicyclists coming from the left often go unnoticed, especially when sight distances are poor.

(4) When constructed in narrow roadway right of way, the shoulder is often sacrificed, thereby decreasing safety for motorists and bicyclists using the roadway.

(5) *Many bicyclists will use the roadway instead of the bicycle path because they have found the roadway to be safer, more convenient, or better maintained. Bicyclists using the roadway are often subjected to harassment by motorists who feel that in all cases bicyclists should be on the path instead.*

(6) *Bicyclists using the bicycle path generally are required to stop or yield at all cross streets and driveways, while bicyclists using the roadway usually have priority over cross traffic, because they have the same right of way as motorists.*

(7) *Stopped cross street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.*

(8) *Because of the closeness of motor vehicles to opposing bicycle traffic, barriers are often necessary to keep motor vehicles out of bicycle paths and bicyclists out of traffic lanes. These barriers can represent an obstruction to bicycles and motorists, can complicate maintenance of the facility, and can cause other problems as well.*

For the above reasons, bicycle lanes, or shared roadways should generally be used to accommodate bicycle traffic along highway corridors rather than providing a bicycle path immediately adjacent to the highway.

An exception to this general rule consists of situations where an off-road path intended for bicycle use must be located adjacent to a roadway for a relatively short distance. In order to maintain continuity of the trail section, it may be preferable in this situation to locate the path adjacent to the roadway. An example of this situation would consist of the joint use of a roadway's bridge by a trail. In such situations, physical separation of the path from the roadway must be provided as discussed later in this chapter.

2. Design of Paths for Bicycle Use

a. Width and Clearance

The paved width and the operating width required for a bicycle path are primary design considerations. Figure 36 depicts a bicycle path. Under most conditions, recommended paved width for a two-directional bicycle path is 10 feet (3 m). In some instances, however, a minimum of 8 feet (2.4 m) can be adequate. This minimum should be used only where the following conditions prevail: (1) bicycle traffic is expected to be low, even on peak days or during peak hours; (2) pedestrian use of the facility is not expected to be more than occasional; (3) there will be good horizontal and vertical alignment providing safe and frequent passing opportunities; (4) the path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage. Under certain conditions it may be necessary or desirable to increase the width of a bicycle path to 12 feet (3.7 m) or more; for example, because of substantial bicycle volume, probable shared use with joggers and other pedestri-

ans, use by large maintenance vehicles, steep grades, where bicycles will be likely to ride two abreast.

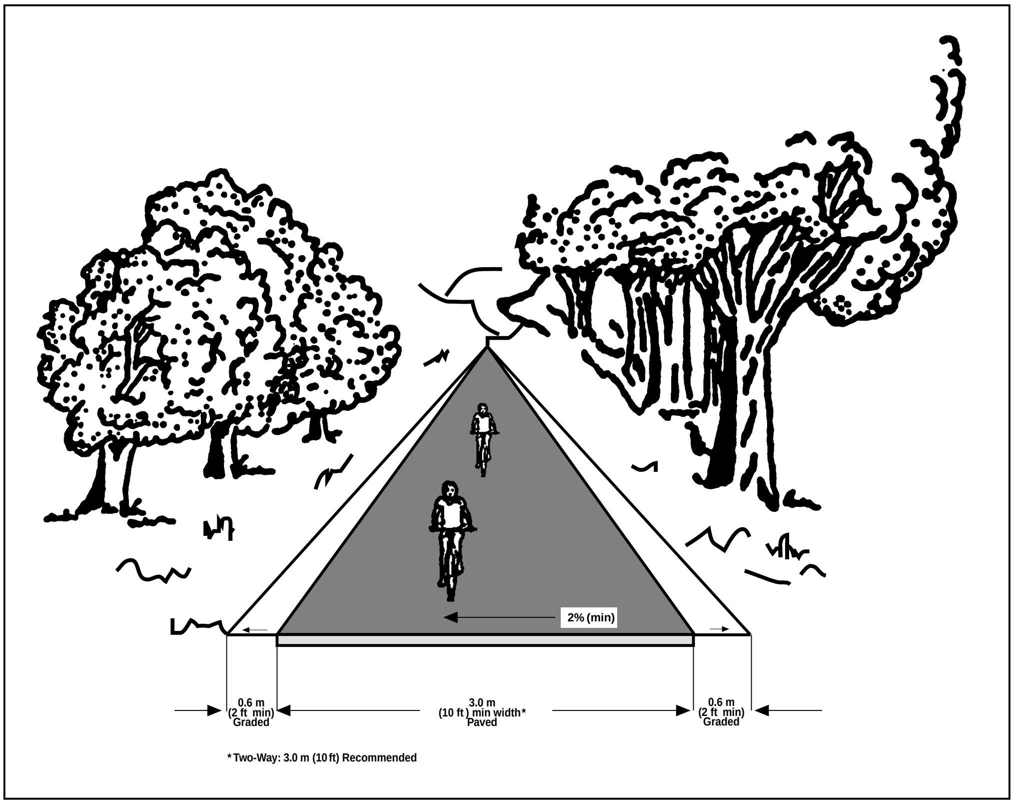
Reduced widths are acceptable on linkage paths. Because of their short length, they seldom allow bicyclists to operate at full speed, and because of low traffic volumes they seldom result in conflicts. However, whenever possible, linkage paths should comply with the minimum width standards presented here.

One directional bike paths are not recommended since they will usually be used as two-way facilities and should be designed accordingly.

A minimum of 2 feet (0.6 m) width graded area should be maintained adjacent to both

Figure 36

Bicycle Path on Separated Right-of-Way



Source: Adapted from Guide for the Development of Bicycle Facilities, AASHTO, 1991

sides of the pavement, however, 3 feet (0.9 m) or more is desirable to provide clearance from trees, poles, walls, fences, guardrail, or other lateral obstructions. A wider graded area on either side of the bicycle path can serve as a separate jogging path.

The vertical clearance to obstructions should be a minimum of 8 feet (2.4 m). However, vertical clearance may need to be greater to permit passage of maintenance vehicles and, in undercrossings and tunnels, a clearance of 10 feet (3 m) is desirable for adequate vertical shy distance.

b. Horizontal Separation from Roadways

Ordinarily, bicycle paths are located where separate right-of-way is available. However, where a bike path is being considered within a roadway right-of-way, *a wide separation between a bicycle path and adjacent highway is desirable to confirm both the bicyclist and the motorist that the bicycle path functions as an independent highway for bicycle traffic. In addition to physical separation, landscaping or other visual buffer is desirable. When this is not possible and the distance between the edge of the roadway and the bicycle path is less than 5 feet (1.5 m), a suitable physical divider may be considered. Such dividers serve both to prevent bicyclists from making unwanted move-*

ments between the path and the highway shoulder and to reinforce the concept that the bicycle path is an independent facility. Where used, the divider should be a minimum of 4.5 feet (1.4 m) high, to prevent bicyclists from toppling over it, and it should be designed so that it does not become an obstruction or traffic hazard in itself.

c. Design Speed

The speed that a bicyclist travels is dependent on several factors, including the type and condition of the bicycle, the purpose of the trip, the condition and location of the bicycle path, the speed and direction of the wind, and the physical condition of the bicyclist. Bicycle paths should be designed for a selected speed that is at least as high as the preferred speed of the faster bicyclists. In general, a minimum design speed of 20 mph (32 km/h) should be used; however, when the grade exceeds 4 percent, a design speed of 30 mph (48 km/h) is advisable.

On unpaved paths, where bicyclists tend to ride slower, a lower design speed of 15 mph (24 km/h) can be used. Similarly, where the grades dictate, a higher design speed of 25 mph (40 km/h) can be used. Since bicycles have a higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction.

d. Horizontal Alignment and Superelevation

The minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate of the bicycle path surface, the coefficient of friction between the bicycle tires and the bicycle path surface, and the speed of the bicycle. The minimum design radius of curvature can be derived from the following formula:

$$R = \frac{V^2}{15\,(e+f)}$$

where: R = *Minimum radius of curvature (ft)*
V = *Design Speed (mph)*
e = *Rate of superelevation*
f = *Coefficient of friction*

For most bicycle path applications the superelevation rate will vary from a minimum 2 percent (the minimum necessary to encourage adequate drainage) to a maximum of approximately 5 percent (beyond which maneuvering difficulties by slow bicycles and adult tricyclist might be expected). The minimum superelevation rate of 2 percent will be adequate for most conditions and will simplify construction.

The coefficient of friction depends upon speed; surface type, roughness, and condition; tire type and condition; whether the surface is wet or dry. Friction factors used for design should be selected based upon the point at which centrifugal force causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. Extrapolating from values used in highway design, design factors for paved bicycle paths can be assumed to vary from 0.30 at 15 mph (24 km/h) to 0.22 at 30 mph (48 km/h). Although there are not data available for unpaved surfaces,it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety.

Based upon a superelevation rate (e) of 2 percent, minimum radii of curvature can be selected from the following table.

When substandard radius curves must be used on bicycle paths because of right of way, topographical or other considerations, standard curve warning signs and supplemental pavement markings should be installed in accordance with the MUTCD. The negative effects of substandard curves can also be partially offset by widening the pavement through the curves.

Table 3

Table 3 Minimum Radii for Paved Bicycle Paths (e = 2 Percent)		
Design Speed-V (mph) (1 mph=1.6 km/hr)	Friction Factor - f	Minimum Radius - R (Feet) (1'=0.3 m)
20	0.27	95
25	0.25	155
30	0.22	250
35	0.19	390
40	0.17	565

e. Grade

Grades on bicycle paths should be kept to a minimum, especially on long inclines. Grades greater than 5 percent are undesirable because the ascents are difficult for many bicyclists to climb and the descents cause some bicyclists to exceed the speeds at which they are competent. Where terrain dictates, grades over 5 percent and less than 500 feet (150 m) long are acceptable when a higher design speed is used and additional width is provided. Grades steeper than 3 percent may not be practical for bicycle paths with crushed stone surfaces.

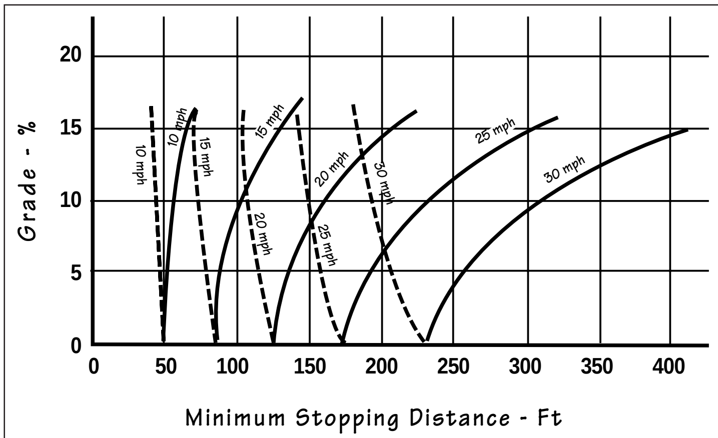
f. Switchbacks

In areas of extremely steep terrain, a series of "switchbacks" may be the only solution to traversing changes in elevation. At these locations, a grade of 8 percent is acceptable for a distance of no longer than 30 meters (100 feet). Grades steeper than 8 percent will not meet *Americans with Disabilities Act* standards. Pavement width should be a minimum of 3.6 meters (12 feet) wide to allow ascending bicyclists to walk. The "switchbacks," or turns should be completely visible from the uphill turn. Runouts at the end of each turn should be considered for bicyclists not able to stop. Railing should be installed to discourage short-cuts, and appropriate signing should be placed at the top of the descent.

g. Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a bicycle path should be designed with adequate stopping sight distance. The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the braking ability of the bicycle.

Figure 37 indicates the minimum stopping sight distance for various design speeds and grades based on a to-



$$S = \frac{V^2}{30(f \pm G)} + 3.67\,V$$

Where: S = Minimum Sight Distance, Ft
V = Velocity, mph
f = Coefficient of Friction (use 0.25)
G = Grade Ft/Ft (rise/run)

Decend (-G) ———
Ascend (+G) - - - - -

(Metric Conversion: 1 Ft = 0.3 m. 1 mph = 1.6 km/h)

Note: See Metric Conversion Tables in appendix.

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

Figure 37

Minimum Stopping Sight Distance

tal perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.25 to account for the poor wet weather braking characteristics of many bicycles. For two-way bicycle paths, the sight distance in descending direction,that is, where "G" is negative,will control the design.

Figure 38 is used to select the minimum length of vertical curve necessary to provide minimum stopping distance at various speeds on crest vertical curves. The eye height of the bicyclist is assumed to be 4.5' (1.4 m) and the object height is assumed to be zero to recognize that impediments to bicycle travel exist at pavement level.

Figure 39 indicates the minimum clearance that should be used to line of sight obstructions for horizontal curves. The lateral clearance is obtained by entering Figure 39 with the stopping sight distance from Figure 37 and the proposed horizontal radius of curvature.

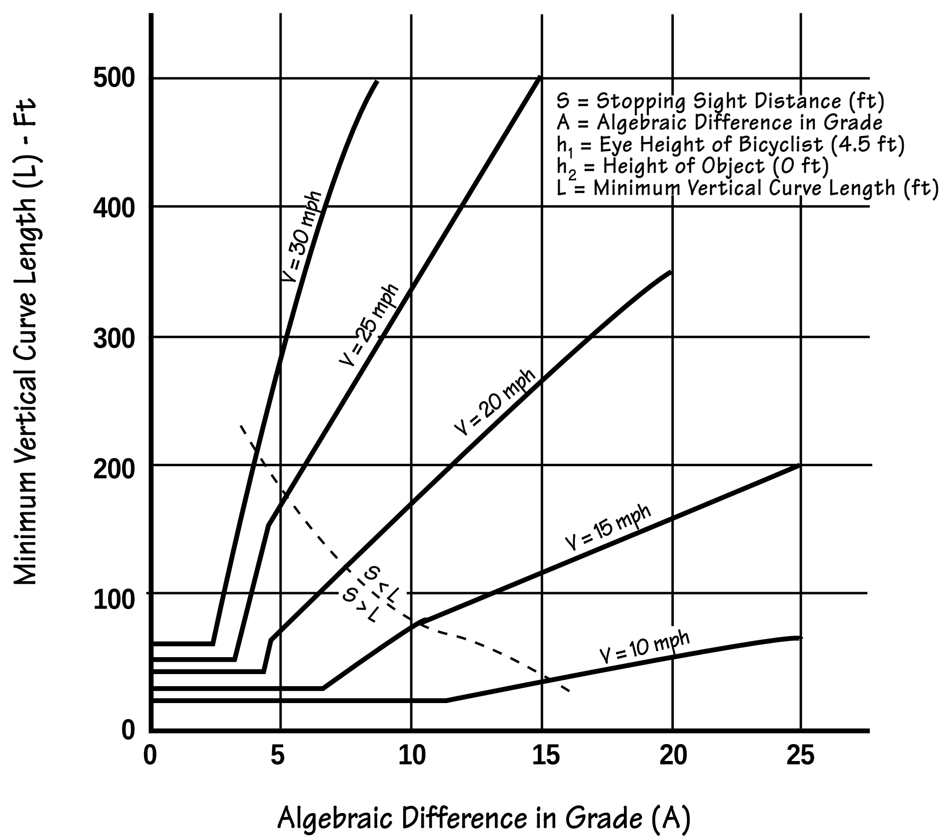
Bicyclists frequently ride abreast of each other on bicycle paths and, on narrow bicycle paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the serious consequences of a head on bicycle accident, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distance for bicyclists traveling in opposite directions around the curve. Where this is not possible or feasible, consideration should be given to widening the path through the curve, installing a yellow center stripe, installing a curve ahead warning sign in accordance with the MUTCD, or some combination of these alternatives.

Figure 38

Minimum Length of Vertical Curves

$$L = 25 - \frac{200(\sqrt{h_1}+\sqrt{h_2})^2}{A} \quad \text{when } S>L \qquad L = \frac{AS^2}{100(\sqrt{2h_1}+\sqrt{2h_2})^2} \quad \text{when } S<L$$

$$L_{MIN} = 2V$$

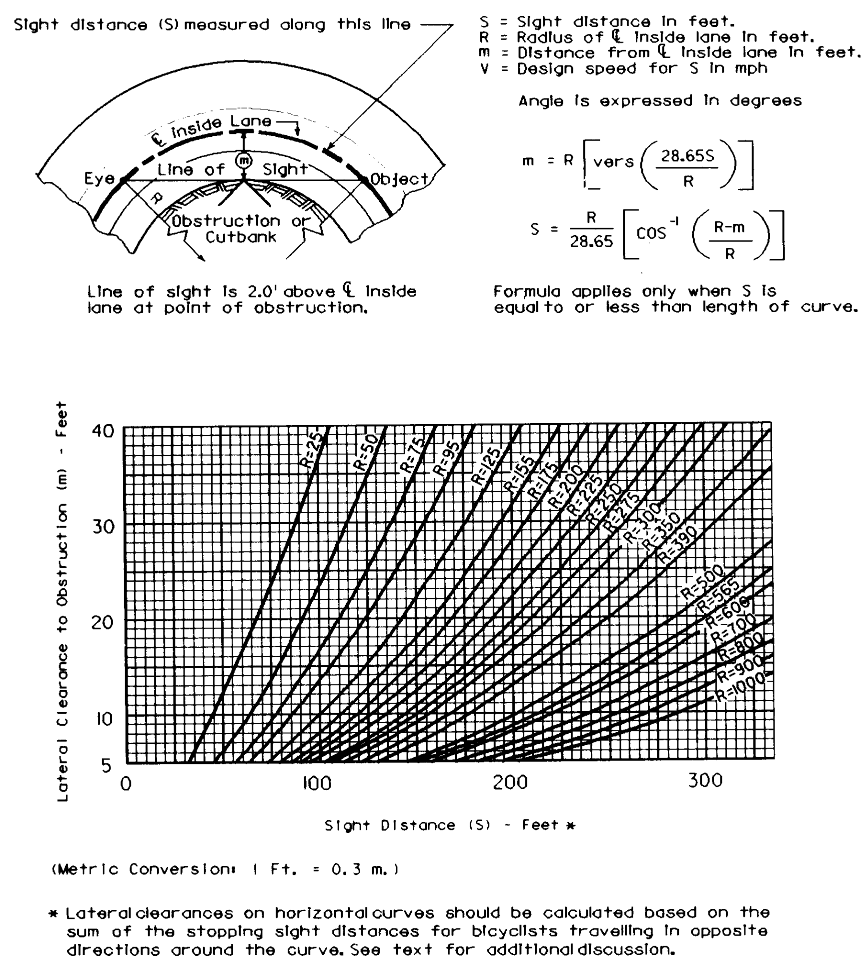


Note: See Metric Conversion Tables in appendix.

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

Figure 39

Minimum Lateral Clearances on Horizontal Curves



Note: See Metric Conversion Tables in appendix.

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

h. Intersections

Intersections with roadways are important considerations in bicycle path design. If alternate locations for a bicycle path are available, the one with the most favorable intersection conditions should be selected. For crossings of freeways and other high-speed, high-volume arterials, a grade separation structure may be the only possible or practical treatment. Unless bicycles are prohibited from the crossing highway, providing for turning movements must be considered.

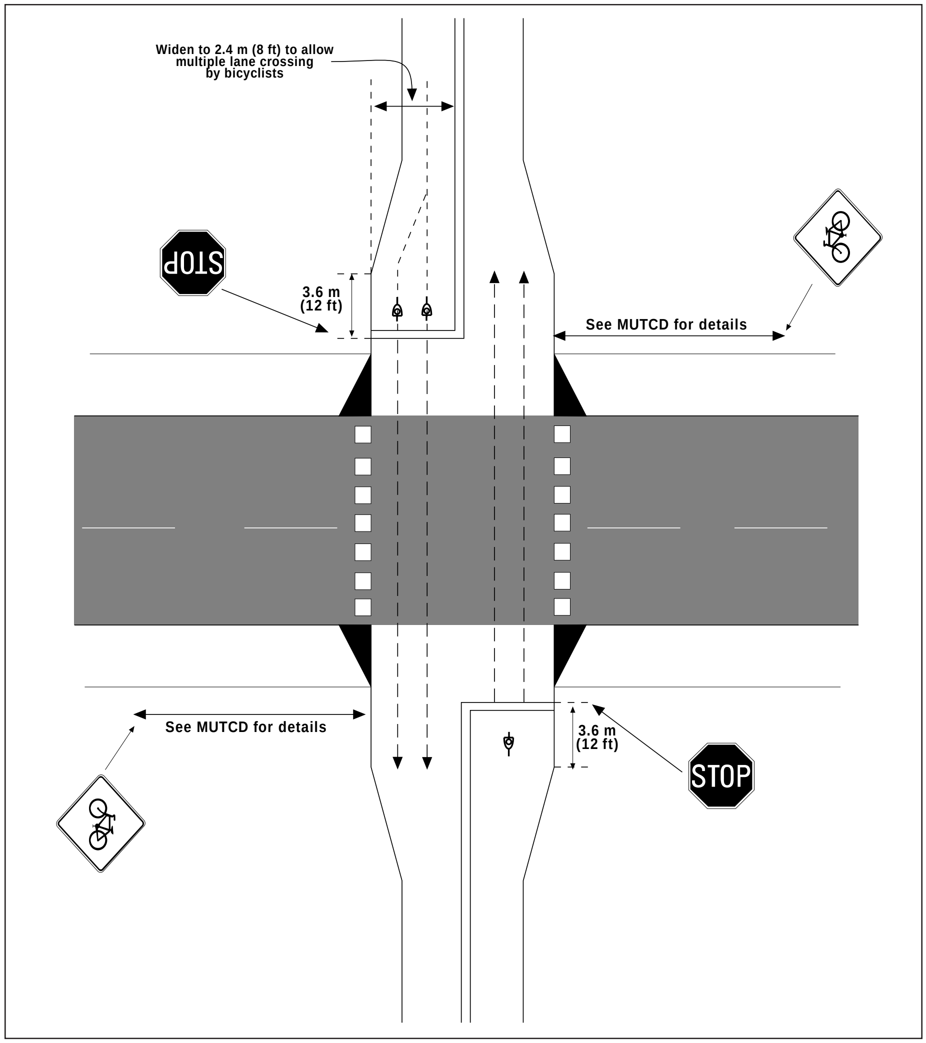
When intersections occur at grade, a major consideration is the establishment of right of way. The type of traffic control to be used (signal, stop sign, yield sign, etc.), and location, should be provided in accordance with the MUTCD (see Figure 40).

Sign type, size and location should also be in accordance with the MUTCD. Care should be taken to ensure that bicycle path signs are located so that motorists are not confused by them and that roadway signs are placed so that bicyclists are not confused by them.

Other means of alerting bicyclists of a highway crossing include grade changes or changing surfaces at the approach (see Figure 41). Devices installed to prohibit motorists from entering the bike path can also assist with alerting bicyclists to crossings.

Figure 40

Intersection of Bicycle Path and 2 Lane Roadway



Source: Adapted from Technical Handbook of Bikeway Design, Velo, Quebec, 1992

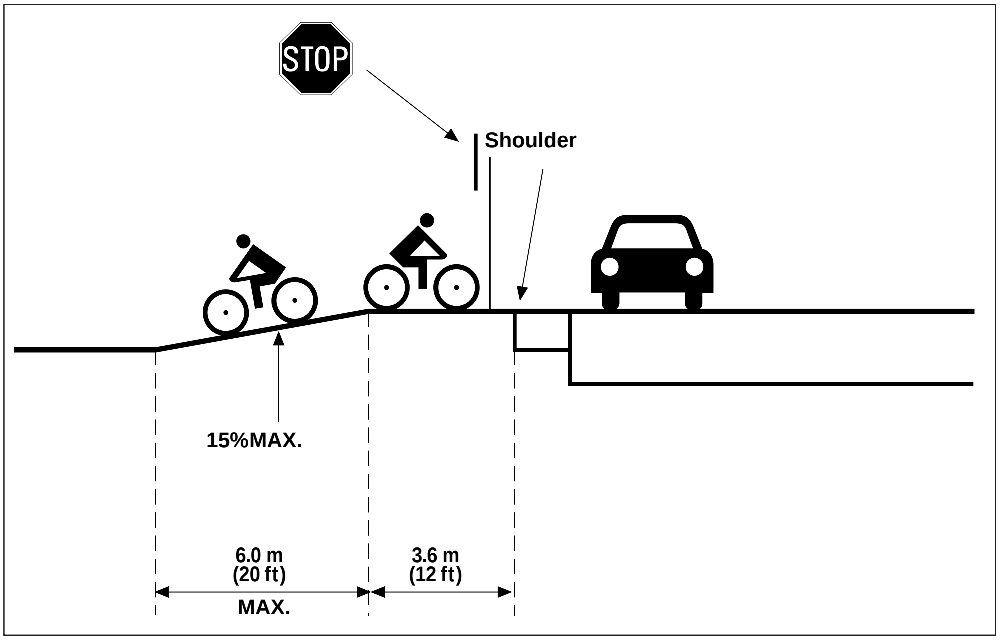
It is preferable that the crossing of a bicycle path and a highway be at a location away from the influence of intersections with other highways. Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and normal Rules of the Road. Where physical constraints prohibit such independent intersections, the crossings may be at or adjacent to the pedestrian crossing. Right of way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements. At crossings of high volume multi-lane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for bicyclists.

When bicycle paths terminate at existing roads, it is important to integrate the path into the existing system of roadways. Care should be taken to properly design the terminals to transition the traffic into a safe merging or diverging situation. Appropriate signing is necessary to warn and direct both bicyclists and motorists regarding these transition areas.

Bicycle path intersections and approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and ad-

equate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades.

Ramps for curb cuts at intersections should be the same width as the bicycle paths. Curb cuts and ramps should provide a smooth transition between the bicycle paths and the roadway.



Source: Adapted from Technical Handbook of Bikeway Design, Velo, Quebec, 1992

Figure 41

Highway Crossing Marked by Grade Change

i. Signing and Marking

Adequate signing and marking are essential on bicycle paths, especially to alert bicyclists to potential conflicts and to convey regulatory messages to both bicyclists and motorists at highway intersections. In addition, guide signing, such as to indicate directions, destinations, distances, route numbers and names of crossing streets, should be used in the same manner as they are used on highways. In general, uniform application of traffic control devices, as described in the MUTCD, will tend to encourage proper bicyclist behavior.

A designer should consider a 4 inch (10 cm) wide yellow centerline stripe to separate opposite directions of travel. This is particularly beneficial in the following circumstances: (1) for heavy volumes of bicycles; (2) on curves with restricted sight distances; and (3) on unlighted paths where nighttime riding is expected. Edge lines can also be very beneficial where nighttime bicycle traffic is expected.

General guidance on signing and marking is provided in the MUTCD. Care should be exercised in the choice of pavement marking materials. Some marking materials are slippery when wet and should be avoided in favor of more skid resistant materials.

j. Pavement Structure

Under most circumstances, a 50 millimeter (2 inch) thick asphaltic concrete top course placed on a 150 millimeter (6 inch) thick select granular subbase is suitable for a bikeway pavement structure as shown in Figure 42. Where unsatisfactory soils

Table 4

Trail Surface Synopsis		
SURFACE MATERIAL	**ADVANTAGES**	**DISADVANTAGES**
Soil cement	Uses natural materials, more durable than native soils, smoother surface, low cost.	Surface wears unevenly, not a stable all-weather surface, erodes, difficult to achieve correct mix.
Granular stone	Soft but firm surface, natural material, moderate cost, smooth surface, accommodates multiple use.	Surface can rut or erode with heavy rainfall, regular maintenance to keep consistent surface, replenishing stones may be a long-term expense, not for steep slopes.
Asphalt	Hard surface, supports most types of use, all weather, does not erode, accommodates most users simultaneously, low maintenance.	High installation cost, costly to repair, not a natural surface, freeze/thaw can crack surface, heavy construction vehicles need access.
Concrete	Hardest surface, easy to form to site conditions, supports multiple use, lowest maintenance, resists freeze/thaw, best cold weather surface.	High installation cost, costly to repair, not a natural looking surface, construction vehicles will need access to the trail corridor.
Native soil	Natural material, lowest cost, low maintenance, can be altered for future improvements, easiest for volunteers to build and maintain.	Dusty, ruts when wet, not an all-weather surface, can be uneven and bumpy, limited use, not accessible.
Wood chips	Soft, spongy surface - good for walking, moderate cost, natural material.	Decomposes under high temperature and moisture, requires constant replenishment, not typically accessible, limited availability.
Recycled materials	Good use of recyclable materials, surface can vary depending on materials.	High purchase and installation cost, life expectancy unknown.

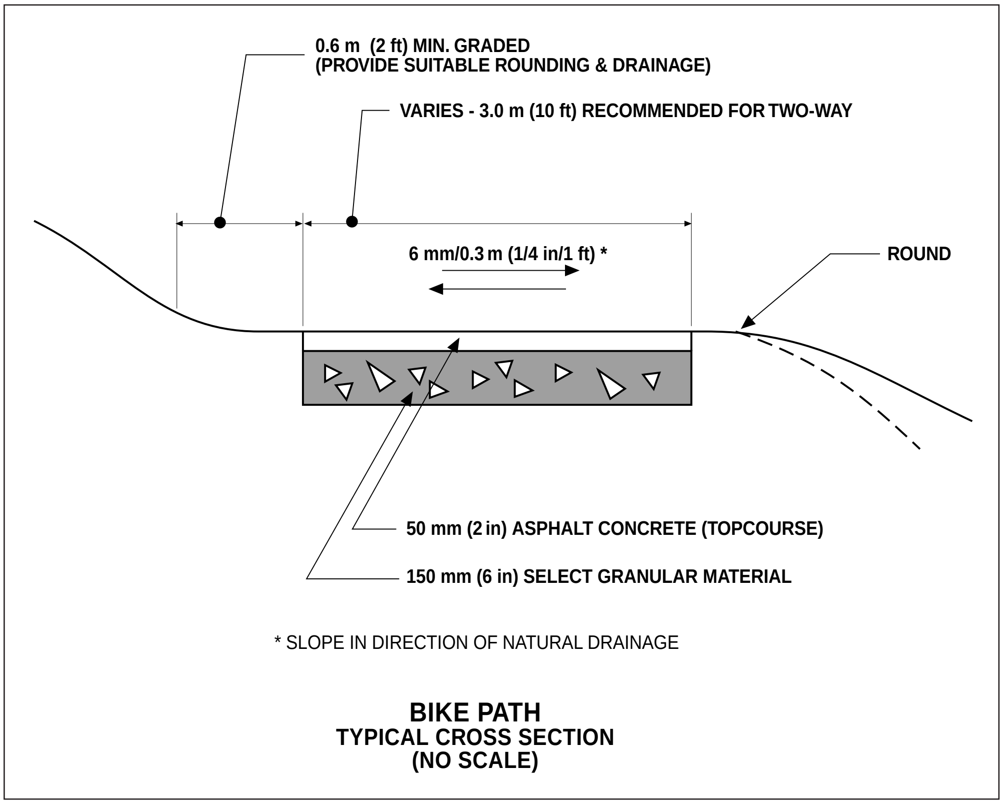


Figure 42

Bikeway Pavement Structure

Source: Adapted from Highway Design Manual, New York State Department of Transportation

can be anticipated, a soil investigation should be conducted to determine the load carrying capabilities of the native soil and the need for any special provisions.

In addition, there are several principles that should be followed to recognize some basic differences between the operating characteristics of bicycles and those of motor vehicles. While loads on bicycle paths will be substantially less than highway loads, paths should be designed to sustain without damage wheel loads of occasional emergency, patrol, maintenance, and other motor vehicles that are expected to use or cross the path.

Conditions where additional pavement structure may be necessary are flood plains, and locations where shallow root systems will upheave a thin pavement section.

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on bicycle paths, their wheels will usually be at or very near the edges of the path. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the path, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or in constructing additional pavement width. Constructing a typical pavement width of 12 feet, where right of way and other conditions permit, eliminates the edge raveling problem and offers two other additional advantages over shoulder construction. First, it allows additional maneuvering space for bicyclists and second, the additional construction cost can be less than for constructing shoulders because the separate construction operation is eliminated.

It is important to construct and maintain a smooth riding surface on bicycle paths. Bicycle path pavements should be machine laid; root barriers should be used where necessary to prevent vegetation from erupting through the pavement; *and, on portland cement concrete pavements, transverse joints, necessary to control cracking, should be sawcut to provide a smooth ride. On the other hand, skid resistance* *qualities should not be sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes, for example.*

In areas where climates are extreme, the effects of freeze-thaw cycles should be anticipated in the design phase. At unpaved highway or driveway crossings of bicycle paths, the highway or driveway should be paved a minimum of 10 feet on each side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles. The pavement structure at the crossing should be adequate to sustain the expected loading at that location.

When a bike path is part of a multi-use trail facility, alternative pavement structure may be appropriate. Particularly because of today's wide profile tires found on hybrid and all-terrain bikes, more bicycles are able to use this surface.

k. Structures

An overpass, underpass, small bridge, drainage facility or facility on a highway bridge may be necessary to provide continuity to a bicycle path. An example of a small bridge structure used to provide bicycle continuity is shown in Figure 43. A bicycle facility on a highway structure is shown in Figure 44.

Figure 43

Bridge Structure to Provide Bicycle Path Continuity

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

On new structures, the minimum clear width should be the same as the approach paved bicycle path; and the desirable clear width should include the minimum 2 foot (0.6 m) wide clear areas. Carrying the clear areas across the structures has two advantages. First, it provides a minimum horizontal shy distance from the railing or barrier, and second, it provides needed maneuvering space to avoid conflicts with pedestrians and other bicyclists who are stopped on the bridge. Access by emergency, patrol, and maintenance vehicles should be considered in establishing the design clearances of structures on bicycle paths. Similarly, vertical clearance may be dictated by occasional motor vehicles using the path. Where practical, a vertical clearance of 10' (3 m) is desirable for adequate vertical shy distance.

Railings, fences, or barriers on both sides of a bicycle path structure should be a minimum of 4.5' (1.4 m) high. Smooth rub rails should be attached to the barriers at handlebar height of 3.5' (1.1 m).

Bridges designed exclusively for bicycle traffic may be designed for pedestrian live loadings. On all bridge decks, special care should be taken to ensure that bicycle safe expansion joints are used.

Where it is necessary to retrofit a bicycle path onto an existing highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow.

One option is to carry the bicycle path across the bridge on one side. This should be done where (1) the bridge facility will connect to a bicycle path at both ends; (2) sufficient width exists on that side of the bridge or can be obtained by widening or restriping lanes; and (3) provisions are made to physically separate bicycle traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where (1) the bicycle path transitions into bicycle lanes at one end of the bridge; and (2) sufficient width exists or can be obtained by widening or restriping.

A third option is to use existing sidewalks as one-way or two-way facilities. This may be advisable where (1) conflicts between bicyclists and pedestrians will not exceed tolerable limits; and (2) the existing sidewalks are adequately wide. Under certain conditions, the bicyclist may be required to dismount and cross the structure as a pedestrian.

Because of the large number of variables involved in retrofitting bicycle facilities onto existing bridges, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best determined by the designer, on a case-by-case basis, after thoroughly considering all the variables.

Source: Guide for the Development of Bicycle Facilities, AASHTO, 1991

Figure 44

Bicycle Facility on a Highway Structure

I. Drainage

The recommended minimum pavement cross slope of 2 percent adequately provides for drainage. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation.

Where a bicycle path is constructed on the side of a hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should be designed in such a way that no undue obstacles are presented to bicyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water under the path. Drainage grates and manhole covers should be located outside of the travel path of bicyclists. To assist in draining the area adjacent to the bicycle path, the design should include considerations for preserving the natural ground cover. Seeding, mulching, and sodding of adjacent slopes, swales, and other erodible areas should be included in the design plans.

m. Lighting

Fixed-source lighting reduces conflicts along the paths and at intersections. In addition, lighting allows the bicyclist to see the bicycle path direction, surface conditions, and obstacles. Lighting for bicycle paths is important and should be considered where riding at night is expected, such as bicycle paths serving college students or commuters, and at highway intersections. Lighting should also be considered through underpasses or tunnels, and when nighttime security could be a problem. Depending on the location, average maintained horizontal illumination levels of 0.5 foot candle (5 lux) to 2 foot-candles (22 lux) should be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. Luminaries and standards should be at a scale appropriate for a pedestrian or bicycle path.

n. Barriers to Motor Vehicle Traffic

Bicycle paths often need some type of physical barrier at highway intersections and pedestrian-load bridges to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable post to permit entrance by authorized vehicles. The post should be permanently reflectorized for nighttime visibility and painted a bright color for improved daytime visibility. When more than one post is used, a 5-foot (1.5 m) spacing is desirable. Wider spacing can allow entry to motor vehicles, while narrower spacing might prevent entry by adult tricycles and bicycles with trailers.

An alternate method of restricting entry of motor vehicles is to split the entry way into two 5 feet (1.5 m) sections separated by low landscaping. Emergency vehicles can still enter if necessary by straddling the landscape. The higher maintenance costs associates with landscaping should be acknowledged, however, before this alternative method is selected.